Air Quality Sensor for Asthma

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Project 3:

Portable Indoor Air Sensor for Teens with Asthma

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Introductory Problem Statement

Asthma is a chronic lung disease that inflames and narrows the airways, making them swollen and very sensitive. Asthma sufferers’ airways tend to react strongly to certain inhaled substances, causing the muscles around them tighten. This narrows their airways, reducing air flow to the lungs.

Asthma symptoms can differ for each person, but the most common symptoms are:

* **Wheezing:** Asthma patients may notice a wheezing sound when they breathe. Sometimes this happens only when they exercise or have a cold.
* **Frequent Cough** **and Shortness of Breath:** This may be more common at night**.**
* **Chest Tightness:** The patient’s chest may feel tight, especially during cold weather or exercise; this may also be the first sign of a flare-up.

Treating symptoms when they are first noticed is important; this will help to prevent the symptoms from worsening, potentially causing a severe asthma attack. Our intent is to design a device that will assist the user in tending to these needs. The BreatheEasy Portable Air Sensor (PAS) will provide a full-package solution for the needs of asthma patients.

To accomplish our goal, the device should have following core functionalities:

* **Personalized Emergency Alerts:** The device should alert the user of dangerous environmental conditions.
* **Peak Flow Meter Readings:** The device should record peak flow meter readings, in order to provide a meaningful picture of the history of the user's condition.
* **Ability to Detect Changes in Environmental Conditions:** The device should be able to sense both inorganic (e.g. dust particles, ozone content, etc.) and organic compounds (e.g. formaldehyde, endotoxin etc.), as well as other atmospheric variables such as temperature or humidity, and to alert the user if changes in these may potentially trigger symptoms.

Our device should also encourage the user to be proactive in treating their symptoms. To this end, the device should possess the following attributes:

* **Ease of Use:** The device should be easy to use and configure, so that it can be adjusted to suit the needs of the user.
* **Lightweight:** The device must be convenient for the user to keep on their person at all times.
* **Persistent Monitoring:** The device should be able to record information regarding the status of the user, in order to provide a complete picture of their health over time.
* **Treatment:** The device should suggest appropriate treatment methods (e.g. administer Ventolin, call a doctor, etc.).

There is no cure for asthma. However, with proper treatment, it can be managed so that asthma patients can live a normal, healthy life.

History, Research, & Current Solutions

Vest-Based Sensors Monitor Environmental Exposure to Help Understand Causes

Researchers at Georgia Tech Institute (GTRI) have developed a sensor system that monitors the air around a person prone to asthma attacks. The sensor is worn in a vest pocket and can measure airborne exposure to volatile organic compounds (VOCs), formaldehyde, carbon dioxide, ozone, nitrogen dioxide, temperature, and relative humidity. This sensor takes a measurement and air sample every two minutes.1 The data is then stored in on-board memory and later analyzed by GTRI. While this device, much like ours, will help determine which pollutants most effect a patient, this device does not act as an early warning sign of poor air quality. Our sensor will span the scope of data collection, distribution, diagnosis, *and* be interactive with the patient. It can and will alert both patient and caregiver of increased pollutants in the environment.

AT&T Solution

AT&T recently developed an asthma VOC detector. It is capable of detecting a wide range of airborne VOCs and then alerting the user when the concentrations might be high enough to trigger an asthma attack. The sensor connects via ZigBee to a smartphone, tablet, or PC. AT&T’s current goal is to show that this sensor can be used by real people in real instances to avoid asthma attacks. The ultimate goal of this device is not to provide immediate interactive help to the asthma patient, however; instead, it is to collect patient data for transmission via AT&T’s new end-to-end infrastructure to the medical personnel. Results of this trial VOC detector are expected at the end of the year.2 This solution mainly focuses on transmitting pollutant information via cloud platform and remote monitoring. It is currently in trial stage, and does not say anything about on-the-spot diagnosis as included in our system.

Propeller Health Tracking Sensors

Propeller Health has designed a tracking mechanism5 wherein a small wireless sensor is attached to an inhaler. This sensor wirelessly updates details to smartphones including the iPhone and Android phones; it also keeps track of the time, frequency, and count of events. The result is personal event tracking and recording system for asthma and Chronic Obstructive Pulmonary Disease (COPD). This device is dependent on mobile apps due to synchronization; it does not, however, include any on the spot diagnosis but instead focuses only on analysis.

Objectives

* **Early Warning:** The device should allow asthma sufferers to be proactive about improving their air quality before symptoms begin. This means that the device should be portable, so that users can keep it on their person at all times. The device should alert the user when airborne pollutants are in the environment and could cause an attack or increased asthma symptoms such as wheezing, coughing, and shortness of breath. It should also alert the user when atmospheric temperatures are at levels that may trigger that specific user’s symptoms and attacks.
* **Diagnostics:** It can be difficult to determine what component of the user’s environment is triggering symptoms. The device should help to determine exactly what is responsible for triggering the user's symptoms.
* **Guidance:** The device should also provide the user with guidance regarding the best course of treatment; this may include whether or not to use a rescue inhaler, ways to reduce the impact of adverse environmental conditions, or even if the user should contact a physician.
* **Reporting:** The device should generate weekly reports. These reports may be sent automatically to the patient, caregivers, physicians, or any other parties chosen by the user. The reports should chart the patient’s weekly progress, including atmospheric conditions, asthma symptoms, medication usage, and peak flow results. This device would also enable the patient to forecast their health conditions a week or two ahead, if the same dosage and medicines are taken regularly. This would give the patient an approximate idea regarding how to maintain or improve their current health level.
* **Configurability:** The device should be configurable by the patient’s physician, specialists, and potentially the user. If desired, the physician should be able to input patient-specific symptoms and respective diagnostic response given by the device. The physician should also be able to entire patient-specific medication information.
* **Usability:** The device should be user-friendly, and have an interface that is simple to understand while under duress. The patient and caregivers may potentially be accessing important diagnostic information from the device and application during an attack, so it is crucial that information be quick and easy to find during these situations.

System Details & Requirements

Core Functionalities:

1. The device should be able to sense in real-time the size and concentration of individual components in the surrounding environment. Such components may include formaldehyde, endotoxin, dust, pollen, etc. The sensor will alert the patient about change in any component if it exceeds a given threshold value.
2. The device should be able to sense in real-time changes in atmospheric variables such as temperature, humidity, etc. and alert the user if it exceeds a given threshold.
3. In case the device senses that the threshold for particles has exceeded, it will set a timer for five minutes in conjunction with alerting the patient. In case the atmosphere does not normalize in that time, an alert will be sent to the parent/caregiver of the patient.
4. The device should notify the parent/caregiver of the exact location of the patient when an emergency alert is sent using GPS.
5. The device should record the readings of peak flow meter results (green, yellow, or red zone) to keep track of the progress of the patient’s asthma symptoms.
6. The device should include a diagnosis mode. In this mode, a series of “yes” or “no” questions will be asked. Based on the patient's answers, the device should provide a suggested course of action.

Some relevant questions might be:

* Are you experiencing shortness of breath?
* Are you experiencing coughing or wheezing?
* Have you been experiencing shortness of breath all day?
* Have you been experiencing coughing or wheezing all day?
* Are you feeling tightness in your chest?

Configurability:

The threshold for various pollutants should be configurable so that it can be set according to the needs of specific patient. The system should also store contact information for both the patient's primary caregiver and at least one emergency contact.

Data Recording:

1. The device should be able to keep data for diagnostic and peak flow records.
2. Storage should be sufficient to store records for two to four weeks in the device.
3. Data transfer should be supported via USB cable in order to transfer diagnostic records.
4. The device should record the concentration levels of each pollutant in the environment at the time of an attack or increased asthma symptoms, as well as charting which pollutants seem most prevalent and are most closely associated with the patient’s attacks.
5. The device should be able to record the conditions present when the user is experiencing symptoms, in order to help determine what is causing them.

Power Source:

The device should be powered by a rechargeable battery. The battery should be able to power the device, during continuous operation, for 48 to 72 hours.

Form Factor:

1. The device should be small in size, and externally wearable (e.g. on a clip, wristband, etc.).
2. The device should be lightweight, optimally less than 1 pound.
3. The device should be sturdy enough not to be damaged by minor impacts and moisture.

User Interface:

1. The menus should be easy to navigate.
2. For each menu, there should be a small, user-friendly “How to Use” video describing the usage of that menu.

Customer Constraints

To summarize, these are the primary constraints that we foresee being required by the customer:

Size:

The device must be as small as possible, so that the user can wear at all times.

Simplicity:

The device must be simple and unassuming; not another “gadget” that user is encumbered by.

Power:

The device must be capable of continued operation without charging for extended periods; again, to avoid saddling the user with another “gadget.”

Cost:

The device should be able to be produced cheaply, so that it is available to as many users as possible without regard for possible financial constraints.

Durability:

If the device is to be used by children and teenagers or, for that matter, worn at all times by anyone, it must be very durable. This includes being resistant to impacts and moisture.

Maintainability:

The device should be able to be easily repaired or replaced in the event that it is damaged or destroyed.

Who Are Our Users?

Americans with Asthma

Think of the five people closest to you; these people may be your significant other, your parents, your children, or even a close friend. According to the Annual U.S. Prevalence Statics for Chronic Diseases, one out of these five people that you know suffers from asthma and allergies. Delving into these statics reveals that the sheer numbers of Americans whose daily lives are significantly impacted from asthma is astounding. Every single day in America 44,000 people have an asthma attack. In the same 24 hour period of time, 36,000 adults will miss work and 27,000 children will miss school due to asthma. Yet, perhaps the most shocking is that 9 Americans will die daily due to asthma.3 Eventually, we hope to assist those with asthma around the world. However, we are going to start our tests in the United States, based on these facts. If the device does well, then we will shift our marketing efforts to the Netherlands and other parts of Europe.

Annual U.S. Prevalence Statistics for Chronic Diseases

Audience

What if you are a chronic asthma patient and you have an attack? Or, perhaps you are the parent or dedicated caregiver of an asthma patient; how can you learn about the status of progress?

Patients:

Today, it is more likely that a patient who is experiencing symptoms will seek help in the form of an inhaler or other medication. However, a teenager or child may not be able to make the correct decisions with regard to their treatment. Our device aims to eliminate this risk by taking proactive measures.

Parents/Caregivers

Our device will address the concerns of parents and caregivers, as it will inform them about the progress of the user, and alert them in the event of an emergency.

Remember, "an ounce of prevention is worth a pound of cure."

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